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Commercial Space Transportation Opportunities in Government Exploration Programs

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Abstract

As more countries and companies pursue exploration of space in low Earth orbit and beyond, new opportunities are available to governments to establish commercial partnerships. Although cooperation between governments is common in international space science, human space flight, communications, and other areas, governments should also consider advantages of purchasing commercial services to meet their exploration objectives. As in any public-private partnership, meeting the needs of both government and commercial industry will be challenging.

Commercial companies can bring the following partnership benefits: lower cost through sharing of resources, increased innovation, greater risk tolerance, and the opening of new markets and creation of new jobs. However, to take advantage of those benefits, governments may have to be flexible in how they approach commercial partnering and change from historical practices in government-run programs.

Commercial space transportation in the United States today can provide insight into partnership challenges and tools available for governments to consider in future exploration for both robotic and human space flight.

In the United States, commercial launch, reentry, and the operation of commercial spaceports is regulated by the Federal Aviation Administration's Office of Commercial Space Transportation, which is part of the U.S. Department of Transportation. "Commercial" in the United States can be defined as operations run by the private sector with vehicles they own. Instead of certifying launch and reentry vehicles, the FAA licenses the launch operation and focuses on public safety. The FAA's licensing regime sets performance-based requirements that give industry the flexibility to meet safety objectives without specifying how safety must be achieved. This enables the industry to grow with less oversight and increases technology innovation. With more flexibility, commercial companies can be safe and meet customer requirements, including those for government-owned payloads, through a launch services contract.

One partnership example is the National Aeronautics and Space Administration's (NASA's) Commercial Crew Program. By investing in a commercial partner, NASA is able to help develop a new human space transportation capability to the International Space Station and at the same time enabling a commercial provider to pursue other potential commercial customers. With potential additional revenue from multiple users, commercial providers can offset the cost and still deliver a vehicle suited to both government and private use. The government can also save significant funding. One of the main challenges of the Commercial Crew Program is to balance all the requirements NASA has (built up from over 50 years of human space flight experience) with those that could be affordable to commercial customers using the same vehicle. To help achieve this balance, the FAA and NASA signed a Memorandum of Understanding (MOU) in 2012 to provide a stable framework for the U.S. space industry, avoid conflicting requirements and multiple sets of standards, and advance both public and crew safety. The FAA will license commercial providers for public safety while crew safety and mission assurance will be NASA's responsibility. This approach allows both agencies to incorporate experience and lessons learned as progress is made.

By considering commercial needs in the establishment of flexible programs, regulations, and law, governments can achieve their goals of exploration and enable private industry to carry out space support activities that used to be only in the domain of government. Exploration support activities can include transportation services for crew and cargo, operation of launch and reentry sites, communications, navigation, energy, space weather forecasts, and supply of raw materials such as from mining planetary bodies. By tapping commercial potential in support services, governments can focus their resources on more difficult tasks in exploration that only governments can do.

This paper will examine how government flexibility is crucial for the first steps in commercial partnerships that governments may wish to consider as they pursue space exploration. Regulatory and policy solutions will be addressed through examples in commercial space transportation.

1. Introduction

Exploration of space began as a government-only endeavor with the commercial sector providing supporting roles through government contracts. Although independent commercial space businesses have developed in satellite communications, launch, global positioning and navigation, ground hardware, and other areas, exploration as a business has generally proven to be elusive. The large investment needed to get into space, explore, and then exploit business benefits from that exploration has been difficult for individual companies to achieve. As a result, exploration has largely remained in the realm of government.

However, in recent years, the idea of exploration by companies has been reenergized as commercial space capabilities have increased. New enterprises have been proposed from mining asteroids and the Moon to sending people to the Moon and around Mars. Concurrently, the number of countries and programs in civil space exploration and science is also increasing. These increases create new opportunities for partnerships between the government sector and the commercial sector.

"Commercial" can be defined as operations run by the private sector with vehicles, spacecraft, or services they own. Typically, the commercial business bears a significant portion of the investment risk and has responsibility for their activities.

Although cooperation between governments is common in international space science, human space flight, deep space communications, and other areas, governments should also consider the advantages of purchasing commercial services to meet their exploration objectives. As in any public-private partnership, meeting the needs of both government and commercial industry is important and challenging.

This paper will look at commercial space transportation services as one of several options for exploration partnerships. NASA's Commercial Orbital Transportation Services program and Commercial Crew Program will be discussed as examples of partnerships.

2. What Can Commercial Companies Bring?

Commercial companies can bring the following partnership benefits: lower cost through sharing of resources, increased innovation, greater risk tolerance, faster pace, the opening of new markets, and creation of new jobs.

To take advantage of those benefits, governments may have to be flexible in how they approach commercial partnering and change from historical practices in government-run programs. This means strategies that benefit both sides and even cultural changes.

3. Exploration and Commercial Services

Civil space exploration opens up new possibilities for commercial companies to provide services to government.

Examples of commercial services include:

- Transportation from Earth to low Earth orbit (or the International Space Station) and return to Earth of cargo and people;
- Transportation of cargo and people to destinations beyond low Earth orbit and return;
- Operation of launch and reentry sites;
- Telecommunications;
- Space weather forecasts and environmental data;
- Navigation;
- Energy;
- Science data;
- Asteroid monitoring, redirection and sensing systems;
- On-orbit satellite and spacecraft repair or servicing; and
- In-situ resource utilization, such as supplying raw materials from mining planetary bodies.

4. Rethinking Government Approaches

In order to access the potential of commercial companies, governments may have to rethink historical approaches on how to reach their objectives.

For example, space weather data can be gathered and sold commercially from space-based platforms such as from a satellite or a hosted payload on a satellite or transportation vehicle. Solar flare eruptions (observed and forecast), coronal mass ejections, solar energetic particles, and geomagnetic/ionospheric storms can degrade the communication/navigation, avionics, alter spacecraft orbit or pose serious health risk to humans. Accurate observations and forecasts are needed. Depending on the type of hazard, the operator may need to take safety measures, such as moving to protected areas inside the vehicle, postponing EVAs, turning off spacecraft sensors, or conducting orbital maneuvers. A commercial space weather provider could provide tailored space weather observations, forecasts, alerts and warnings for other satellites, transportation vehicles, and people in space. A provider could monitor a vehicle's trajectory and alert the crew of approaching areas of elevated radiation levels, orbital debris, or meteoroids/micrometeoroids.

Buying data instead of hardware can simplify the government's role and unleash innovative solutions from industry through competition. The government may only need to set minimal requirements about constructing the hardware.

If a technology or capability is new and needs more research and development, a prize competition may be a powerful incentive as was seen with the Ansari XPrize. Private industry and academia may spend more trying to win the prize then the value of the prize itself. It would also be possible to demonstrate new technologies or sensors by using hosted payloads on another satellite or space vehicle.

Another option is to share access to government expertise in unfunded partnerships to develop new space products. NASA released a request for information called Collaborations for Commercial Space Capabilities in 2013 for "existing and new companies and non-profit organizations to access NASA's spaceflight expertise for mutually beneficial space exploration goals."[1]

Having the government partner with companies may enable industry to open new markets or enable a company to compete better in an existing market. The government may have to be an anchor tenant, but ideally, it would not be the only customer in the long term. Certainly, industry motivation may be greater when investing its own funding.

5. Commercial Space Transportation in the U.S.

Commercial space transportation in the United States today can provide insight into how flexible approaches by government can enable commercial potential for both robotic and human space flight missions.

In the United States, commercial launch, reentry, and the operation of commercial spaceports is regulated by the Federal Aviation Administration's Office of Commercial Space Transportation, which is part of the U.S. Department of Transportation. A commercial launch in the United States is a launch or reentry carried out by the private sector. The FAA does not license launches that the U.S. Government carries out for the government. Instead of certifying launch and reentry vehicles, the FAA licenses the launch operation and focuses on public safety. The FAA's licensing regime sets performance-based requirements that give industry the flexibility to meet safety objectives without specifying how safety must be achieved. This enables the industry to grow with less oversight and increases technology innovation. With more flexibility, commercial companies can be safe and meet customer requirements, including those for government-owned payloads, through a launch services contract. The Office of Commercial Space Transportation was created with passage of the 1984 Commercial Space Launch Act (51 USC, Chapter 509) at a time when launch vehicles were being privatized and new launch vehicles were being developed for commercial purposes.

Since 1989, the FAA has licensed over 220 commercial launches to both suborbital and orbital destinations. The FAA has also granted permits for over 30 launches of suborbital reusable launch vehicles since 2006. Permits were established in the U.S. for suborbital testing and research and development. All of the licensed and permitted launches were completed without any significant property damage or loss of life, meeting the FAA's primary safety objectives.[2] At the same time, industry is able to meet the needs of its customers and/or grow into new markets.

6. Commercial Orbital Transportation Services Program

After the decision to retire the Space Shuttle, NASA created the Commercial Orbital Transportation Services (COTS) program to demonstrate cargo resupply of the International Space Station (ISS). The COTS program successfully enabled the development of two new expendable launch vehicles and rendezvous and return spacecraft: SpaceX's Falcon 9 and Dragon, and Orbital Sciences' Antares and Cygnus.

Key to COTS success was the use of innovative Space Act Agreements available to NASA under the 1958 National Aeronautics and Space Act (51 USC, Chapter 201). Space Act Agreements allow NASA to partner with industry in a variety of ways in order to leverage commercial investment and business practices without extensive government requirements.[3] Under COTS, commercial companies led the development and demonstrated their own cargo space transportation capabilities, while NASA provided technical and financial assistance. The FAA licensed the COTS demonstration launches and reentries, since they were carried out by industry. Instead of "contractors," NASA had

"partners." Payments by NASA were made only upon completion of progress milestones by industry. The competitive COTS program was done as fixed price procurement.

This innovative procurement approach yielded significant cost savings to the U.S. Government. Before the program was completed, a 2011 study by NASA on SpaceX Falcon 9 cost estimates compared "1) traditional NASA environment/culture, and 2) a more commercial development culture approach." The results of the study, which used the NASA-Air Force Cost Model (NAFCOM), found that: "…Falcon 9 would cost $3.977B based on NASA environment/culture. NAFCOM predicted $1.695B when all technical inputs were adjusted to a more commercial development approach." As to actual costs, NASA made $396 million in payments to SpaceX for COTS (including the Falcon 9 and Dragon capsule)[4] and SpaceX spent about $300 million of its own money on Falcon 9 development.[5] The Falcon 9 was based on investment SpaceX made on the Falcon 1.

From the commercial perspective, development of the Falcon 9 allowed SpaceX to compete for international commercial market customers. After the first Falcon 9 geosynchronous orbit satellite launch on December 3, 2013, SpaceX reported it had 50 launch orders on its manifest with "over 60%" of them for commercial customers.[6] Orbital Sciences expects to announce its first commercial launch contract customer in 2014. During the 2000s, U.S.-manufactured vehicles lost commercial launch market share to competitors in Europe, Russia, and the multi-national company, Sea Launch.

The COTS program was completed in 2013 as both SpaceX and Orbital Sciences advanced into commercial resupply services contracts under the Federal Acquisition Regulations for the ISS. These launches and/or reentries are also licensed by the FAA.

7. Commercial Crew Program

NASA is attempting a similar COTS procurement approach with government and commercial co-investment in the Commercial Crew Program (CCP). The CCP will facilitate development of a U.S. commercial crew space transportation capability to achieve safe, reliable, and cost effective access to and from low Earth orbit and the ISS. NASA will perform insight/oversight on the commercial partner's design, development, and certification process to evaluate an end-to-end crew transportation system.

Commercial companies will be able to pursue other customers besides NASA with the vehicle they develop. Success could open up commercial space travel to low Earth orbit and other destinations for the private sector. Among the benefits listed by NASA for the Commercial Crew Program are: reducing reliance on foreign systems and to "free NASA's limited resources for beyond-LEO capabilities."[7]

NASA top level requirements for commercial crew space transportation include: 1) "delivering four astronaut crew members and equipment to the space station and returning them to Earth at least twice a year;" 2) assuring crew safety in an emergency on the launch pad and during launch and ascent to orbit; 3) ability to stay docked to the ISS for at least 210 days; and 4) be able to demonstrate a 24-hour "safe haven" during an emergency in space.[8]

Through August 2013, NASA has spent about $1.1 billion on commercial crew development efforts.[9] After an initial competition, NASA is currently working with three companies: SpaceX, Boeing, and the Sierra Nevada Corporation. A capsule design is being developed by SpaceX and Boeing while Sierra Nevada is planning a winged lifting body. The current schedule calls for completion of the CCP development phase in 2017.

8. Challenges in Commercial Crew Program

Use of a Space Act Agreement, while giving commercial companies more leeway, limits NASA's ability to dictate specific design and safety requirements during the development process and makes oversight more challenging.[10]

According to a NASA requirements document in 2010: "Certification of a commercial space transportation system during development/demonstration and procurement of services, rather than the space system itself, represents a significant departure from the way NASA has approached human spaceflight in the past. Agency policy does not

currently mandate human rating for anything but NASA developments. However... Agency policy does require NASA to analyze the risk and decide on necessary steps for safety when putting NASA personnel in harm's way using designs or operations that NASA does not control. … This certification will apply to NASA missions only (i.e. those carrying NASA or NASA sponsored crew members). … NASA will not be involved in the certification of commercial systems when they are used for other purposes."[11]

In 2011, the CCP developed and released a set of requirements and standards called the 1100 series which outlines about 300 requirements for NASA missions to the ISS. The standards "cover every aspect of safety, from ground processing and providing a crew with optimal breathing air and life support systems to ensuring the reliability of a spacecraft's windows and computer circuit boards."[12]

According to Chris Gerace, Deputy Chief of CCP's Systems Engineering and Requirements Office, "Our partners can be as creative as they want when it comes to their designs, but they've got to meet the intent of these standards before they can fly a NASA crew."[13] Former NASA CCP manager, Ed Mango said, "What we want is innovation. So, if we're meeting the intent of our requirements, we are more than willing to talk about different verification methods with our partner. As long as the intent has not changed and the risk that requirement is trying to negate is being accounted for."

In December 2012, NASA awarded specific Certification Products Contracts to the three commercial crew partners worth about $10 million each to ensure that commercial vehicles align with NASA certification requirements. Each company will prepare a certification plan to include data from engineering standards, tests, and analyses of their crew transportation systems design. The companies can propose alternate standards for certification. A second phase of the certification process in 2014 will be subject to a full and open competition. The second phase will include the final development, testing, and verifications necessary to allow crewed demonstration flights to the space station.

One of the main challenges of the Commercial Crew Program is to balance all the requirements NASA has acquired and used from over 50 years of human space flight experience with those that a commercial company can accommodate without stifling innovation or technology development. In the end, these systems must be safe and affordable to their commercial customers using the same vehicles.

In addition to extensive discussions between industry and NASA on requirements, to help achieve a requirements balance, the FAA and NASA signed a Memorandum of Understanding (MOU) in 2012. The MOU seeks to provide a stable framework for the U.S. space industry, avoid conflicting requirements and multiple sets of standards, and advance both public and crew safety. The FAA will license commercial providers for public safety while crew safety and mission assurance will be NASA's responsibility. This approach allows both agencies to incorporate experience and lessons learned as progress is made.

In 2013, the FAA released a draft guidelines document for commercial space transportation called "Established Practices for Human Space Flight Occupant Safety."[14] The FAA used the requirements for the NASA Commercial Crew Program to capture areas of FAA concern for human space flight. The draft document could serve as a starting point for future federal rulemaking, although the FAA has no current plans to develop new regulations. Currently, the FAA is restricted by law until 2015 from implementing rules to protect people onboard space transportation vehicles.

Another challenge for NASA is cultural. Former Space Shuttle manager, N. Wayne Hale and Exploration Systems chief engineer, Frank Bauer, recommended a change from oversight to insight in a 2010 NASA Headquarters white paper in order to achieve the right balance for safety in the Commercial Crew Program. Hale and Bauer addressed cultural change for NASA by stating that: "Clearly, the recommendations proposed herein represent a culture shift in the way NASA has built and flown its previous human spaceflight vehicles. The government team will need to transform from their traditional role as "controllers" to become "influencers" with judicious, discrete control opportunities. As with any culture change, outstanding, effective culture change leadership is needed within the commercial crew leadership team to move the agency on the right course."[15]

9. Conclusion

Commercial companies increasingly have the potential to carry out space support and operational activities that used to be only in the domain of government. By considering commercial needs in the establishment of flexible partnership programs, regulations, and law, governments can achieve their goals of exploration and enable commercial industry to enter new markets. By tapping commercial potential, governments can focus their resources on more difficult tasks in space exploration that only governments can do.

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[2] For more information about the FAA Office of Commercial Space Transportation, see http://www.faa.gov/about/office_org/headquarters_offices/ast/

[3] For more information on Space Act Agreements and commercial partnering, see http://www.nasa.gov/open/plan/space-act.html. By March 2013, "NASA reported over 1,500 active Space Act Agreements with various private companies, educational institutions, state and Federal government organizations, and foreign governments and entities ("Commercial Cargo: NASA's Management of Commercial Orbital Transportation Services and ISS Commercial Resupply Contracts," NASA Inspector General, IG-13-016, June 13, 2013, page 1. http://oig.nasa.gov/audits/reports/FY13/IG-13-016.pdf).

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